Value of diffusion-weighted MR imaging as an early surrogate parameter for the response of colorectal metastases to interstitial 192Ir-High-dose-rate brachytherapy

O. Dudeck1, C. Wybranski1, M. Zeile1, D. Löwenthal1, F. Fischbach1, M. Pech1, G. Wieners1, and J. Ricke1
1Radiology and Nuclear Medicine, Otto-von-Guericke University, Magdeburg, Sachsen-Anhalt, Germany

Introduction:
Image guided single fraction high dose rate (HDR) brachytherapy is a high precision percutaneous ablation technique that has been shown to yield promising results with regards to safety and efficacy in the treatment of irresectable liver metastases [1]. Goal of this study was to investigate the value of changes of the apparent diffusion coefficient (ADC) as an early surrogate parameter for the response of colorectal metastases following CT- and MRI-guided HDR brachytherapy. Diffusion-weighted imaging (DWI) is an imaging method to supply information of water proton mobility, which can be employed to assess the microstructural organization of tissue [2]. Preclinical and clinical studies revealed DWI to represent a sensitive biomarker for the early detection of cellular changes in treated tumors, which closely correlated with macroscopic volumetric responses [3].

Material and methods:
We evaluated 40 colorectal liver metastases in 30 patients treated with CT- and MR-guided HDR brachytherapy. Pre- and post interventional imaging included fat saturated T2w FSE and Gd-EOB-DTPA enhanced T1w GRE sequences for the evaluation of tumor morphology as well as diffusion-weighted echoplanar (EPI-DWI) sequences. Imaging was performed in median 1 day before (baseline MRI) as well as 2 (early MRI) and 90 days (follow-up MRI) after ablation. Tumor diameter (TD) and ADC were evaluated independently by two experienced radiologists. Changes of TD and ADC on follow-up were assessed with use of the Wilcoxon test, the relationship of TD and ADC with the Pearson correlation coefficient. A p value of 0.05 was considered statistically significant.

Results:
Tumor response in treated lesions was 100% with no local progression being noted within the follow-up interval. Mean TD and ADC at baseline MRI were 38±25 mm as well as 1.78±0.46 x 10⁻³ mm²s⁻¹. On early MRI, mean TD was 39±26 mm, which resembled an increase by 1±2 mm (p=0.012). At the same time mean ADC decreased significantly by -0.09±0.13 x 10⁻³ mm²s⁻¹ to 1.60±0.42 x 10⁻³ mm²s⁻¹ (p<0,001). On follow-up MRI, a decrease in mean TD of -8±10 mm to 30±21 mm was noted (p<0,001), while mean ADC increased by 0.27±0.32 x 10⁻³ mm²s⁻¹ to 2.22±0.51 x 10⁻³ mm²s⁻¹ (p<0,001). The Pearson correlation coefficient of changes in TD and ADC was -0.565.

Conclusions:
Changes in ADC can be assessed as soon as 2 days following interstitial ¹⁹²Ir-HDR brachytherapy. This early decrease most likely reflected therapy induced cell swelling, while late increase was the result of apoptotic cell death and reduced tumor cell density.

References:

A: Gd-EOB-DTPA enhanced T1w GRE image prior to HDR brachytherapy displays a liver metastasis in segment 7 with a diameter of 31 mm (top) and a mean ADC of 1.32±0.9 x 10⁻³ mm²s⁻¹ (bottom).
B: A single applicator is positioned percutaneously by MR-guidance within the lesion (top). HDR brachytherapy dose planning is performed by means of computed tomography data (bottom; red circle indicates 20 Gy isodose).
C: Early Gd-EOB-DTPA enhanced T1w GRE image obtained 3 days after HDR brachytherapy reveals a tumor diameter of 32 mm (top), while mean ADC decreases to 1.07±0.6 x 10⁻³ mm²s⁻¹ (bottom).
D: Follow-up Gd-EOB-DTPA enhanced T1w GRE image after 90 days shows a shrinkage of tumor diameter to 22 mm (top), which correlates with an increase to 2.21±1.5 x 10⁻³ mm²s⁻¹ of mean ADC (bottom).